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Summary

The work described in this thesis considers autonomous robots in an environment that is not well understood or modelled at the design stage. In such a poorly understood environment, it is not possible to develop and validate adequate robot controllers a priori; therefore, the robots need to be able to adapt their behaviour to suit various conditions.

To illustrate our concept of adaptation, consider the controller of a robot as a process that maps inputs, read from the robot's sensors and internal states, to outputs, typically actuator and state settings. Learning can then be defined as any change to the mapping between inputs and outputs. Learning in robots can take hours for simple tasks but possibly days or weeks for more complex tasks. Learning is in essence trial and error, and therefore it stands to reason that multiple robots that learn together, i.e. robot-to-robot learning, can offer advantages. This thesis aims to investigate whether and under what circumstances the potential benefits of robot-to-robot learning occur.

The main contribution of this thesis is an in-depth analysis of the benefits of robot-to-robot learning on top of individual learning. Individual learning takes place within a single robot that adapts the controller based on its own experience. Robot-to-robot learning requires more robots as it amounts to changing the controller based on another robots experience. We choose to adapt the controller through evolutionary algorithms. As a result, this thesis belongs to the research field of evolutionary robotics.

The field of evolutionary robotics originated in the late 1980s and aims to create robotic controllers with evolutionary algorithms. These algorithms are

inspired by Darwin’s theory of the survival of the fittest. In nature, animals survive and procreate when they are more suited to their environment. Similarly, a robotic controller is tested by observing the behaviour of the robot and is given a corresponding fitness measure. The higher the fitness of the controller, the higher its chance to procreate.

Robot-to-robot learning is implemented by sharing controllers between robots. Results show that robot-to-robot learning usually results in increased learning speed and increased performance compared to individual learning only. These results are in line with the current literature. However, we discovered an additional benefit of robot-to-robot learning. We show that robot-to-robot learning can reduce the sensitivity of the learning process to the choice of parameter values. This reduction in sensitivity is visible in two ways: an increase in the number of successful runs and a decrease in the number of bad performing individuals. These two effects are similar to the effects desirable when tuning parameters. Therefore, we argue that robot-to-robot learning could be an alternative to the tuning of parameters.

While these results can explain the difference in observations of the benefits of social learning in the current literature, they do not explain why robot-to-robot learning results in benefits. We show that the benefits of robot-to-robot learning depend on the complexity of the task to learn, i.e. the complexity of the fitness landscape with one or multiple peaks. Specifically, the results show that a simple task (a unimodal problem) benefits from more knowledge sharing among robots, while a more complex task (a multi-modal problem) requires a better balance between robot-to-robot learning and individual learning for the best results.